CHAPTER THREE: METHODOLOGY

3.1 BASIC METHOD OF STUDY

The study is mainly based on two parts: (1) case study and (2) general survey study to include case study and general study. The case study was aimed at surveying and collecting data on a state-of-the-art basis taking a suitable hospital for sample survey in Teluk Intan. The other part of the case study was conducted to survey the final treatment and disposal of clinical wastes in an incinerating plant operated in Kamunting Incineration plant.

General survey covered the entire Northern States of Peninsular Malaysia, Sabah and Sarawak. A general comparison of the findings was made with the data of the rest of the country, in order to make it more comparative. Additionally, the government and private hospitals in other states, their locations, medical facilities, bed capacities, occupancy rates etc were also included in this study. The Malaysian clinical waste volume and generation per occupied bed were compared with data from other countries, to make the study globally comparable.

By carrying out the case study, various aspects of clinical waste including source generation points, characteristics, grouping, quantification, types of wastes, treatment etc were studied and surveyed. The second part of the case study provided details about thermal treatment and disposal of clinical waste.

The study was carried out with the cooperation of the consultants (Faber Mediserve Sdn Bhd) and para-medical support staff members of Teluk Intan District hospital and Kamunting bio-medical waste incineration plant.

3.2 PRECAUTIONARY PERSONAL PROTECTION

As a mandatory requirement, immunization against tetanus and hepatitis 'B' was taken prior to survey. Personal protective measures were also adopted while carrying out the survey.

3.3 TELUK INTAN DISTRICT HOSPITAL

The District Hospital in Teluk Intan of Perak State was chosen for this study. Five site study visits were carried out. The detailed waste study was carried out in the following departments:

General and Medical, Accident and Emergency, Labour, Physiotherapy, Orthopedic surgery, General and othropedic surgery, Dental surgery, Gynaecology and Outpatients departments. Apart from above departments, the other wards (Table 3.1) were also visited to survey the wastes handling activities of the hospital.

Most of the wards had bed capacities of 14 and 28 with a make shift facility for 4 additional beds. Each ward was annexed with a special care section where patients deserving continuous monitoring were admitted. Certain wards like General and Orthopedic care were found located in different locations of the same premises for convenience. Each ward was found to be provided with one or two yellow clinical waste bag holder and bins of 45 and 70 litre capacity. The number of bins varied according to ward strength and size. The bags were changed as and when required by the Faber Medi Serve consortium staff with the cooperation of ward nursing staff.

Table 3.1 Wards in Teluk Intan District Hospital

S No.	Ward Name/Ward Number	Ward Department
1	ICU	Intensive Critical Unit
2	CCU	Coronary Care Unit
3	1A	Orthopedic
4	1B	Ophthalmic
5	1C	General Surgery
6	2C	Medical
7	1B	Burnt Injury
8		Psychiatric Ward
9	GA	Prenatal/Postnatal
10	GD	Therapeutic Ladies
11	1D	Orthopedic Surgery
12	SCN	General
13	OP	Out patients
14	D	Dental care

Non-clinical wastes from facilities such as staff canteen, general stores, laundry, maintenance rooms, support services administrative offices, commissary and outpatients registration counters were not studied. These wastes are disposed like any other municipal wastes, by the municipal waste collectors.

3.4 WASTE QUANTIFICATION

The clinical wastes generated in the hospitals were quantified by weight. The wastes collected in different wards in small yellow bags of varying sizes were put in a large yellow bag before being weighed. Hospital wastes of non-clinical origin were carefully source separated before disposal. While clinical waste was handled with much care, non-clinical wastes were disposed like any other wastes

Tabletop balances with a weighing capacity of 1 to 15 kg were used by Hospital/MOH Malaysia administration for this purpose. In addition, the waste management consortium used a large platform-weighing machine to quantify the bulk before being sent to the in-house cold storage room. The bags were carefully sealed and tagged with details such as date, weight in kilograms, hospital name and documentation details.

3.5 KAMUNTING CLINICAL WASTES INCINERATOR PLANT

Kamunting Clinical Wastes Incinerator Plant owned and operated by Faber Medi-Serve Sdn. Bhd. was taken as a case study for waste disposal by thermal method. The operational procedures of the incinerator were observed and investigated. Stack emission analysis were also carried out.

3.5.1 STACK EMISSION ANALYSIS

Stack Gas Velocity and Volumetric Flow Rate

Flue gas velocity in the stack was measured using an S-type Pitot tube connected to a manometer pressure gauge. The stack gas velocity and particulate measurements were carried out at the sampling port provided on the stack. The gas velocity and volume flow rate were measured and calculated in accordance with US EPA Method 2 (1972).

3.5.2 Temperature

The temperatures of stack gas and sampled gas through the stack sampler unit were measured using calibrated type K thermocouples and the readings were displayed digitally on the stack sampling equipment. Temperature was also measured by mercury thermometer for reconfirmation.

3.5.3 Moisture content

Determination of moisture content in the stack gas was carried out according to US EPA method 4 (1972) whereby a measured volume of stack gas was bubbled through

a series of chilled impingers each containing 100 ml of water and then drawn through a silica gel filter impinger. The moisture in the stack gas was calculated based on the total change in volume of water in the impingers and weight change of the silica gel in the last impinger.

3.5.4 Measurement of emissions gaseous composition

The composition of stack gas (oxygen, carbon dioxide, carbon monoxide, sulfur dioxide and nitrogen oxide) was determined in situ by using a portable gas analyzer (ENERAC, USA, MODEL 2000E). The equipment was operated by drawing in a small sample of stack gas which was then detected by a number of gas sensors. The analysis mechanism was based on group electrochemical cells equipped with a selective diffusion membrane. At each analysis, readings of the gas were recorded every minute over a period of five minutes, and then averaged to obtain mean concentrations of each gaseous component. The methods are equivalent to US EPA Method 3A, 6C and 7E (1972).

3.5.5 Smoke density

The smoke density was determined using Ringleman Chart consisting of graded shades of grey scales between white and black for judging the blackness of smoke.

3.5.6 Total particulate concentration

The in-stack particulate concentration was measured according to US EPA Method 5 (1972) whereby a measured volume of stack gas was withdrawn isokinetically through a nozzle, which had a sharp and tapered leading edge. Particulate matter was collected on a pre-weighed glass fiber filter located in an oven set at temperature 110°C above the dew point of water to avoid water vapor from condensing. The concentration of particulate matter in the stack gas was determined by the difference in weight of the filter before and after sampling.

3.5.7 Sulphuric Acid mist and/or Sulphur trioxide

The determination of sulfuric acid mist in the stack gas was carried out using US EPA Method 5 sampling train whereby a measured volume of stack gas was withdrawn isokinetically through two impingers each containing 100 ml of chilled isopropyl alcohol and 5% H_2O_2 solutions. The solutions were then analyzed by ion chromatography based on procedure equivalent US EPA 8 (1972).

3.5.8 Hydrochloric Acid (HCl)

The determination of Hydrochloric acid and Hydrogen chloride in the stack gas was carried out using the US EPA Method 5 sampling train whereby a measured volume of stack gas was withdrawn isokinetically through two impingers each containing 100 ml of chilled demineralized water. The samples were analyzed for chloride by ion chromatography. The total chloride response is expressed as HCl. The procedure is equivalent to US EPA 26 methodology.

3.5.9 Fluorides/Hydrofluoric acid (HF)

Similarly, the determination of fluorides in the stack gas was carried out using the US EPA Method 5 sampling train whereby a measured volume of stack gas was withdrawn isokinetically through two impingers each containing 100 ml of chilled dilute sodium hydroxide . The solutions were analyzed for fluoride by using ion chromatography. The fluoride concentration was expressed as HF.

3.5.10 Hydrogen sulfide

Hydrogen sulfide (H_2S) concentration was measured using a gas bubble sampling train by aspirating a measured volume of air through the first impinger containing 3% peroxide scrubbing solution (for SO_2 removal) and second impinger containing cadmium hydroxide solution. The collected sample was subsequently analyzed using spectrophotometer upon addition of methylene blue into the sample solution. The method selected has a sensitivity range of 0.008 to 50 ppm and it is widely applicable

in the industry. The procedure is equivalent to Victorian EPA standard analytical Procedure B18 for Hydrogen sulfide (1972).

3.5.11 Heavy metals analysis

The determination of heavy metals Arsenic (As), Antimony (Sb), Cadmium (Cd), Copper (Cu), Mercury (Hg), Lead (Pb), and Zinc (Zn) in the stack gas was carried out using the US EPA Method 5 sampling train whereby a measured volume of stack gas was withdrawn isokinetically through a series of two impingers each containing 100 ml of chilled potassium permanganate-nitric acid solution and deionized water, respectively. Both the filter and absorbing solutions were analyzed for heavy metals using the following technique:

- Arsenic, Antimony, Cadmium, Copper, Lead and Zinc were determined by Graphite Furnace Atomic Absorption spectroscopy (US EPA SW-846),
- Mercury was determined by cold vapor Atomic Absorption Spectroscopy (US EPA SW-846).

3.5.12 Total (Volatile) Organic Compounds (VOCs)

In the determination of total organic compounds in the stack gas, a measured volume of stack gas was drawn through an activated carbon tube to trap any organic compounds present in the gas according to EPA Standard Analytical Procedure B20. Samples were analyzed by gas chromatography coupled to a flame ionization detector. The total response was measured relative to haxane standard.

3.5.13 Polychlorinated Dibenzo-p-Dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)

The sampling protocol of US EPA Method 23 was adopted to collect the sample using a modified US EPA Method 5 sampling train. A measured volume of stack gas was withdrawn isokinetically through XAD2 resin and a series of impingers containing chilled deionized water. The XAD2 resin was pre-spiked prior to sampling with isotopically labeled dioxin/furan surrogate standard. The filter and the resin were sent

to the United Kingdom for the analysis of PCDDs and PCDFs using a high resolution mass spectrometry in accordance with US EPA Method 1613A.

3.5.14 INCINERATOR RESIDUE ASH ANALYSIS

A sample of residual ash was collected from the incinerator, following a typical day's use. The ash sample as received was weighed and was then physically screened for removal of glass and metallic content, which were quantified. The residual ash was then divided into two sub-samples. Sub-sample one was dried at 120 °C followed by muffle furnacing at 850°C to constant weight.

Sub-sample two was subjected to a standard leaching test whereby 100 g of samples were mixed with 1,000 mls of deionised water and allowed to stand for 24 hours at controlled temperature. After filtering, the filtrate was analyzed for heavy metals [Arsenic (As), Antimony (Sb), Cadmium (Cd), Copper (Cu), Mercury (Hg), Lead (Pb), and Zinc (Zn).]